



Stock Market Efficiency Under the Cost of Carry Model: Evidence from the Spanish Market

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ABSTRACT

This paper studies the conceptual framework of the calculation of the theoretical price of the future based on the cost of carry model and assesses the results of applying this model to the closing prices of the Spanish Market for 2007-2015. Whilst most of the research carried out into market efficiency and the arbitrage opportunities are focused on time series analysis with minute interval, this study analyses the efficiency at the end of the day. This information is particularly relevant to assess the efficacy of the hedging strategy in the daily accounting results of mutual and pension funds, insurance companies and other asset management portfolios. The results obtained suggest that the Spanish Stock Market can be considered efficient, since there are no significant differences between the market and the theoretical price of the future on IBEX 35. The effect of volatility in market efficiency has also been tested, with the result that the most volatile part of the sample presents an absolute percentage error which almost doubles that of the least volatile. Recent negative interest rate period has been separately analyzed too in order to assess an eventual source of inefficiency: no significant impact has been observed in that respect.

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1. Introduction

When the market risk of a group of financial positions is null and there is a possibility of making a profit as a result of market inefficiency, there is an incentive to make an arbitrage deal. In our case, for example, if there would be a profit from buying today a basket of stocks replicating the index and selling simultaneously a future on the index, we would be carrying out a direct or cash-and-carry-arbitrage. The upward press on stock prices for the spot purchase and the downward tension on short positions on the future will lead to an equilibrium position in which there would not be incentive to arbitrage. Additionally, a possibility of arbitrage could exist if there would be a profit by short selling the stock basket portfolio and buying a future on the index, then we would be talking about an inverse or reverse cash- and- carry-arbitrage.

The remainder of this article is organized as follows: The development of the equation of the theoretical price of the future, based on the non-arbitrage condition is developed in section 2. A description of the different versions of the future price proposed in prior work is presented in section 3. In section 4, the empirical results from prior research is analysed. In section 5 the cost of carry model is applied to the considered period (2007-2015) to assess the market efficiency at closing daily prices, giving particular attention to volatility and negative interest rates effects.

2. The Theoretical Price of the Future

Assuming no commissions on the necessary transactions to perform an arbitrage, the theoretical price of the future is derived from the direct and inverse non arbitrage condition:

Direct or cash-and-carry-arbitrage Buy spot and sell future	Inverse or reverse cash-and-carry-arbitrage Sell future and by spot
<p>At inception date:</p> <ol style="list-style-type: none"> 1. We borrow an amount of S_t at an interest rate $r_{t,T}$ for a period $T-t$, time in years to the maturity of the future. 2. We buy a portfolio replicating the index amounting to S_t. 3. We sell a future at a price F_t, maturity T. 4. Dividends to be received up to maturity are assumed to be known. We contract forward rate agreements (FRAs sold) to ensure the interest rates at which dividends will be reinvested up to T. <p>During the deal:</p> <ol style="list-style-type: none"> 5. We receive the dividends, which will be re-invested at the forwards rates, previously contracted. <p>At maturity T, the result has to be zero so there is no incentive to arbitrage</p> <ol style="list-style-type: none"> 6. We sell the portfolio at price S_T. 7. We pay the interest plus the principal of the loan: $-S_t (1 + (T-t) \cdot r_{t,T})$ 8. The m dividends we have received, capitalized at the forwards rates $\bar{r}_{\tau_i,T}$ will be converted into: $D^* = \sum_{i=1}^m D_i (1 + (T - \tau_i) \cdot \bar{r}_{\tau_i,T}) \quad (1a)$ <p>Where τ_i represents the time in years from the moment t up to the respective moments in which the dividends are going to be received until maturity.</p> 9. The settlement of the future takes place with a pay-off $F_t - S_T$ <p>The result of the deal in T equalized to zero will be:</p> $S_T - S_t (1 + (T-t) \cdot r_{t,T}) + D^* + F_t - S_T = 0 \quad (2a)$ 	<p>At inception date:</p> <ol style="list-style-type: none"> 1. We borrow the stocks that replicate the index. 2. We sell the stocks in the market for an amount S_t, which is invested at an interest rate $r_{t,T}$ up to maturity T. 3. We buy a future at a price F_t, maturity T. 4. The lender of the stocks asks for the dividends when paid. Therefore, we have to hedge through forwards (FRAs bought) the interest rates to be paid for the amounts to be borrowed each time a dividend proceed has to be paid to the stocks lender. All those borrowed amounts will be written off at T. <p>During the deal:</p> <ol style="list-style-type: none"> 5. We are paying the dividends to the lender of the stocks at the time they are received from the amounts we borrowed which were hedged at the forward rates at the inception date. <p>At maturity T, the result has to be zero so there is no incentive to arbitrage</p> <ol style="list-style-type: none"> 6. We receive an amount of: $S_t (1 + (T-t) \cdot r_{t,T})$ <p>from the capital invested resulting from the sale of the stocks, plus the interest.</p> 7. We buy the stocks in the market so as to return them to the borrower amounting to $-S_T$. 8. We pay back the loans used to fund the dividends plus the interest at a financial cost of $\bar{r}_{\tau_i,T}$ $-D^* = -\sum_{i=1}^m D_i (1 + (T - \tau_i) \cdot \bar{r}_{\tau_i,T}) \quad (1b)$ 9. The settlement of the future takes place, receiving $S_T - F_t$, resulting in: $S_t (1 + (T-t) \cdot r_{t,T}) - S_T - D^* + S_T - F_t = 0 \quad (2b)$
<p>From (2a) and (2b) we have the theoretical price of the future in both cases, is:</p> $F_t = S_t (1 + (T-t) \cdot r_{t,T}) - D^* \quad (3)$	

3. Versions of the Formula for Theoretical Price of the Future in the Financial Literature

In the financial literature that analyses the relationship between the spot and future prices, the researchers have tried to answer two types of questions: the first one, what is the degree of compliance of the cost of carry model and, consequently, if there are or there are not arbitrage opportunities in the intra-day dealing; and the second, whether one of the markets leads the prices and the other follows this. Research regarding the compliance of the cost of carry model at the end of the day is less frequent.

Regardless of the final goal, all the analysis uses the definition of the theoretical price of the future as a starting point, which presents different forms that are detailed below. The equation (3) $F_t = S_t(1 + (T-t) \cdot r_{t,T}) - D^*$ indicates the price of a financial future to be paid when there is not an incentive to perform an arbitrage buying the spot portfolio and selling the future or vice versa. This way to express the price of the future is, in fact, the one which reproduces an actual deal in the market. This formula has been defined by Fabozzi and Kipnis (1989), Lafuente and Novales (2003) and Lárraga et al. (2008).

If the interest rates expectations theory holds (Mascareñas 2011), the equation (1a) can be expressed as:

$$D^* = \sum_{i=1}^m D_i (1 + (T-\tau_i) \cdot \bar{r}_{\tau_i,T}) = \sum_{i=1}^m D_i \frac{1 + (T-t) \cdot r_{t,T}}{1 + (\tau_i - t) \cdot r_{t,\tau_i}} = (1 + (T-t) \cdot r_{t,T}) \sum_{i=1}^m D_i \frac{1}{1 + (\tau_i - t) \cdot r_{t,\tau_i}}$$

Let D be the sum of the present value of all dividends to be received, discounted at t with their respective spot rates:

$$D = \sum_{i=1}^m \frac{D_i}{1 + (\tau_i - t) \cdot r_{t,\tau_i}} \quad (4)$$

Then, we have:

$$D^* = (1 + (T-t) \cdot r_{t,T}) \cdot D \quad (5)$$

Replacing in (3):

$$\begin{aligned} F_t &= S_t (1 + (T-t) \cdot r_{t,T}) - D (1 + (T-t) \cdot r_{t,T}) \Rightarrow \\ F_t &= (S_t - D) (1 + (T-t) \cdot r_{t,T}) \end{aligned} \quad (6)$$

The intuition behind the above expression is that when a dividend payment is produced at inception, the index will adjust the equivalent points of this dividend and, consequently, the price of the future will also be adjusted. If the dividend is received at a later date, we will have to calculate its present value by discounting it using the spot rate. Examples of the definition of the future price following equation 6, can be found in Sutcliffe (2006) and Puttonen (1993a and 1993b).

Other authors such as Cornet and French (1983); Figlewski (1984); Yadav and Pope (1990), Chung (1991); Stoll and Whaley (1993); Buhler and Kempf (1994); Miller et al (1994) and Neal (1996) prefer a version of equation 3 in which continuous capitalization is applied to both the spot and the dividends, that is to say:

$$F_t = S_t e^{(T-t) \cdot r_{t,T}} - \sum_{i=1}^m D_i e^{(T-\tau_i) \bar{r}_{\tau_i, T}} \quad (7)$$

Wang (2007), Techarongrojwong (2008), Hull (2009) and Fassas (2010) apply the continuous capitalization version of the equation 6:

$$F_t = (S_t - \sum_{i=1}^m D_i e^{-r_{t,T}(\tau_i - t)}) \cdot e^{r_{t,T}(T-t)} \quad (8)$$

Other authors consider simultaneously the continuous capitalization of the underlying asset at a rate r and the continuous distribution of dividends at a rate q . In this way, the net cost of financing the spot position for a direct arbitrage is determined by the interest paid for the money borrowed in the market minus the dividends received which produce a compensation effect of the financial cost. Thus the theoretical price of the future can be expressed as:

$$F_t = S_t e^{(T-t)(r_{t,T} - q)} \quad (9)$$

This way of expressing the price of the future can be found in Bailey (1989) Climent and Pardo (1996) Lafuente (1999), Ganley and Trebeschi (2000), Lafuente and Novales (2003), Roll, Schwartz, and Subrahmanyam (2007), Richie et al (2008), Białkowski and Jakubowski (2008), Alexander and Barbosa (2008) and McMillan and Phillip (2012).

Lindahl (1991) applies a constant dividend rate following the formula:

$$F_t = S_t + S_t (r_{t,T} - q) \quad (10)$$

Considering a continuous dividend rate introduces a significant error in the analysis of the price of the future, since to a lesser or greater degree, the firms that compose the indices concentrate

the dividend payments at determined dates. An example of the effect of dividend concentration for the S&P 500 can be witnessed in Gastineau and Madansky (1983).

4. Findings from Prior Research

The first analysis over the compliance of the cost of carry model at the end of the day was carried out by Figlewsky (1984), just after the incorporation of stock index futures to the market in 1982 in the United States.

Figlewsky achieved, for the closing prices of S&P 500, June 1982-September 1983, an average difference between the actual price of the future and its theoretical one of 0.21%, with a standard deviation of 1%. He concluded that although the difference was statistically significant, it tended to disappear over the time.

Bailey (1989), using the metrics *Mean Percentage Error (MPE- equation 11)* and *Mean Absolute Percentage Error (MAPE-equation 12)* achieved errors of $MPE = -0.25\%$ and $MAPE = 0.8\%$ between the actual and the theoretical price of the future for the Nikkei, following the *cost of carry* model for September 1986 – March 1987.

$$MPE = \sum_{i=1}^n \frac{1}{n} \frac{F_{c_i} - F_{t_i}}{F_{t_i}} \quad (11)$$

$$MAPE = \sum_{i=1}^n \frac{1}{n} \frac{|F_{c_i} - F_{t_i}|}{F_{t_i}} \quad (12)$$

Where:

F_t : Theoretical price of the future at t

F_c : Market price of the future at t

These differences can be considered relatively high with respect to those obtained in more advanced stages of the futures markets in Japan and could be due to both the early stage development of the market and the fact that Bailey used the continuous dividend expression to compute the theoretical price (equation 9).

Yadav and Pope (1990) analysed the compliance of the *cost of carry* model for the FTSE-100 for daily closing prices from June 1984 - June 1988, calculating the deviation between the actual and the theoretical price of the future as:

$$MPE^* = \sum_{i=1}^n \frac{1}{n} \frac{F_{c_i} - F_{t_i}}{I_{t_i}} \quad (13)$$

The obtained average error was 0.40% with a maximum-minimum range of -5.85% to 2.06%. Again, these differences can be considered as significant and could be caused by the inefficiency of the U.K. futures market at that early stage of development, but also because of the use of the index price in the denominator instead of the future price. This could considerably differ on some occasions due to the effect of dividend payments and capitalization of the spot to the expiration of the future.

Wang (2007) analysed the compliance of the *cost of carry* model for the Nikkei, the Hang Seng and the Kospi achieving the following results for 1997-2005 (table 1):

Table 1

Difference between the market and the theoretical price of the future. Japan, Hong Kong, Korea

Stock Index	Percentage Error		Absolute Percentage Error	
	(PE)		(APE)	
	Mean (MPE)	Standard Deviation	Mean (MAPE)	Standard Deviation
Nikkei 225 (Japón)	-0.04%	0.36%	0.26%	0.25%
Hang Seng (Hong Kong)	-0.13%	0.63%	0.41%	0.50%
Kospi 200 (Corea del Sur)	-0.38%	1.78%	1.00%	1.52%

Source: Wang (2007)

As shown, Wang's research points out that in less developed markets (usually, also less efficient) the difference between the actual and the theoretical price of the future is higher.

Replicating Wang's methodology, Techarongrojwong (2008) obtained for the Thai market (2006-2008), the detailed results below (table2), supporting once more that less developed markets are less efficient.

Table 2**Difference between the market and the theoretical price of the future. Thailand**

Stock Index	Percentage Error		Absolute Percentage Error	
	(PE)		(APE)	
	Mean (MPE)	Standard Deviation	Mean (MAPE)	Standard Deviation
SET 50 (Tailandia)	-1.37%	6.67%	4.76%	4.86%

Source: Techarongrojwong (2008)

Fassas (2010) analysed the behaviour of the *cost of carry* model for the closing daily prices in the Greek market (ATHEX-20) for the sample 2004-2009. Applying the equation 13 he calculated an $MPE^* = -0.67\%$ with standard deviation of 0.75% and a variation range of -4.7% to 1.7% .

5. Application to the Spanish Market (2007-2015)

We are now going to analyse if the *cost of carry* model holds for the Spanish stock market at the daily closing prices. That is to say, if the theoretical price of the future on IBEX 35 is equal to its actual price in the market.

Data

The data series needed to calculate the theoretical price of the future is: IBEX 35 closing prices; replicating portfolio stock dividends and interest rates to be applied to the spot position. To assess the eventual arbitrage opportunities and, therefore, the Spanish stock market efficiency, we will also need the next-to-expire IBEX 35 future prices.

IBEX 35 prices: official closing prices at the end of the day, from Sociedad de Bolsas S.A. historical data base.

Interest rates: EONIA and one month EURIBOR rates from the Interbank Market from EURIBOR-EBF historical data base.

The interest rate a trader pays so as to finance the spot position (direct arbitrage) or receives when the proceeds from the short selling are invested (inverse arbitrage) will depend on the internal interest rate that his financial institution applies for these kinds of transactions. This

rate should include the external funding cost as well as the cost of equity. In practice the sovereign bond repo rate (risk free) or the LIBOR (EURIBOR) rates are used. The LIBOR rates are preferred by us instead of the repos since the former represents better, in our opinion, the rate at which a trader will fund the spot position of the direct arbitrage. However, it is true that in the inverse arbitrage, the proceeds from short selling could be invested both in the Interbank or the repo markets. In practice, as indicated by Hull y White (2013) “For non-collateralized transactions, most dealers continue to use LIBOR rates for valuation (p. 3)”.

Dividends: the daily dividends of the sample time period series can be obtained from the historical database of IBEX 35 IMPACTO DIVIDENDOS (Sociedad de Bolsas Españolas), as we will explain in the methodology section.

Price of the future: we have built the series from the MEFF official database by filtering the closing prices of the next-to-expire IBEX 35 future contract.

Methodology

The main objective in this study is to calculate the theoretical price of the future and to compare the result with that of the actual price in the market for each of the closing prices in the period 2007-2015. In case the differences are not significant we may conclude that the cost of carry model holds. As secondary goals, the impact of volatility and negative interest rates scenario would also be subject to analysis.

Let:

F_t Theoretical Price of the future at inception time t ,

I_t Spot Price of IBEX 35 at t

T Time from t to maturity of the future in years

τ_i Dates in which the dividends are received $t < \tau_i < T$ in years

D_{τ} Dividend to be received at moment τ

$r_{t,T}$ Market interest rate until maturity of the future

$\bar{r}_{\tau_i,T}$ Forward interest rate from the moment in which the dividend is received to the maturity of the future

F_c Market Price of the future at t

From the formula of the theoretical price of the future (equation 3), where the spot of the underlying asset is the IBEX 35 = I_t expressed in index points, and presenting the formula to identify the theoretical basis of the future disclosed in its three components¹, we have:

$$F_t = I_t + \left[I_t \cdot (T-t) \cdot r_{t,T} - \sum_{i=1}^m D_i - \sum_{i=1}^m \bar{r}_{\tau_i,T} \cdot D_i \right] \quad (14)$$

The impact of the capitalization of the dividends in the theoretical price of the future has been assessed using the formula:

$$\frac{\sum_{i=1}^m \bar{r}_{\tau_i,T} \cdot D_i}{F_t} \quad (15)$$

So as to determine its relevance, we have taken the index future contract with the highest dividend during the researched period (165.9 points of IBEX 35), which corresponds to the May 2011 contract. The effect over the price of the future², with an abnormal assumption of a high interest rate of 10% is 5×10^{-5} , therefore in our analysis we will disregard the third component of the theoretical price of the future and use the expression:

$$F_t = I_t + \left[I_t \cdot (T-t) \cdot r_{t,T} - \sum_{i=1}^m D_i \right] \quad (16)$$

Where:

- I_t is taken directly from the database.

- $r_{t,T}$ is obtained through linear interpolation between EONIA and one month EURIBOR rates.

-The dividends D_i are obtained from the *IBEX 35 IMPACTO DIVIDENDOS (IMP)*, being

$$D_i = IMP_{\tau_i} - IMP_{\tau_i-1}.$$

Once the theoretical price of the future was obtained, we compared the outcome with that market price.

¹ The theoretical basis in brackets can be broken down into, respectively: the spot position cost of funding, the dividends to the next-to-expire future contract, and the capitalization of those dividends until the maturity of that contract.

² April 15th, 2011 was a Monday, the first trading day for the next-to-expire future contract. In this case two effects concurred: the highest amount of dividends to be received and the longest time to expiration. As a consequence, the result was the highest effect of the capitalization of dividends in the theoretical price of the future.

The analysis has been performed on the following series: All sample (AS), Only Future Maturity Dates (OFMD), Clean Sample (CS) =AS-OFMD, Clean Sample Interest Negative (CSIN), Clean Sample Interest Positive (CSIP), Clean Sample 100 observations Most Volatile (CSMV), Clean Sample 100 observations Least Volatile (CSLV).

The daily closing level of the IBEX 35 is built with the closing spot prices at 17:35. Conversely, the daily settlement price of its future contract is calculated as the weighted average of its executed transactions between 17:29 and 17:30, except for the future maturity dates, whose settlement is fixed as the IBEX 35 average price between 16:15 and 16:45 (one value per minute). Though in regular days there is a slight asynchrony between the spot and the future closing time, in the case of OFMD it is much more significant, so a separate analysis needs to be performed to clean that effect. Additionally, to evaluate the effect of volatility and the recent negative interest rate scenario, the rest of the above mentioned series have also been considered.

Outcomes: Differences between the market and the theoretical price of the future (IBEX 35: 2007-2015)

The main outcomes of this research are: 1) The maturity dates of the future contracts present inefficiencies three times higher than those of the regular days; 2) No significant differences have been found between the market and the theoretical prices of the future on IBEX 35; 3) The most volatile part of the sample presents an error almost double that of the least volatile; and 4) The recent period of negative interest rates had no significant impact in market efficiency. The detailed results are displayed in tables 3 and 4:

Table 3

Percentage error between the market and the theoretical price. IBEX 35 2007-2015

Sample	Percentage Error (PE)					
	N	Mean (MPE)	Standard Deviation	Max	Min	PE>0
All sample (AS)	2293	-0.02%	0.17%	2.29%	-1.50%	43.5%
Only Future Maturity Dates (OFMD)	108	-0.05%	0.56%	2.29%	-1.50%	44.4%
Clean Sample (CS) =AS-OFMD	2185	-0.02%	0.13%	0.61%	-0.73%	43.5%
Clean Sample Interest Negative (CSIN)	208	0.02%	0.15%	0.61%	-0.73%	58.7%
Clean Sample Interest Positive (CSIP)	1977	-0.03%	0.12%	0.52%	-0.68%	41.9%
Clean Sample Most Volatile (CSMV)	100	-0.06%	0.16%	0.52%	-0.47%	32.0%
Clean Sample Least Volatile (CSLV)	100	-0.01%	0.10%	0.32%	-0.25%	42.0%

Table 4**Absolute Percentage error between the market and the theoretical price. IBEX 35 2007-2015**

Sample	Absolute Percentage Error (APE)				
	N	Mean (MAPE)	Standard Deviation	Max	Min
All sample (AS)	2293	0.11%	0.14%	2.29%	0.00%
Only Future Maturity Dates (OFMD)	108	0.38%	0.41%	2.29%	0.00%
Clean Sample (CS) =AS-OFMD	2185	0.09%	0.09%	0.73%	0.00%
Clean Sample Interest Negative (CSIN)	208	0.11%	0.10%	0.73%	0.00%
Clean Sample Interest Positive (CSIP)	1977	0.09%	0.09%	0.68%	0.00%
Clean Sample Most Volatile (CSMV)	100	0.13%	0.12%	0.52%	0.00%
Clean Sample Least Volatile (CSLV)	100	0.08%	0.07%	0.32%	0.00%

The column PE>0 in table 3 represents the *cash and carry* arbitrage opportunities to buy the spot portfolio and sell the future contract. The value for the AS and CS series is 43.5%, therefore, the opportunities for a *reverse cash and carry* arbitrage are higher ($1-43.5\%=56.5\%$). This asymmetric behaviour could possibly be due to the relative difficulty to take short positions in the stocks and also to the short selling restrictions which took place in Europe after September 2008 and continued during the financial crisis. The research performed by McMillan and Philip (2012 p.135) for 52 European stocks, of which six were from the Spanish stock market, points to that direction: "...it is believed that a short-sale constraint on the spot asset would retard the arbitrage process and affect the equilibrium...; our research provides evidence as to whether that is indeed the case." This effect has been particularly noticeable for the CSMV which could point out in the direction of a higher difficulty in the short selling activity during the high volatile periods. Conversely, the *reverse cash and carry* opportunities are lower than those of the *direct* arbitrage in the case of negative interest rates, which could be an interesting subject for further research.

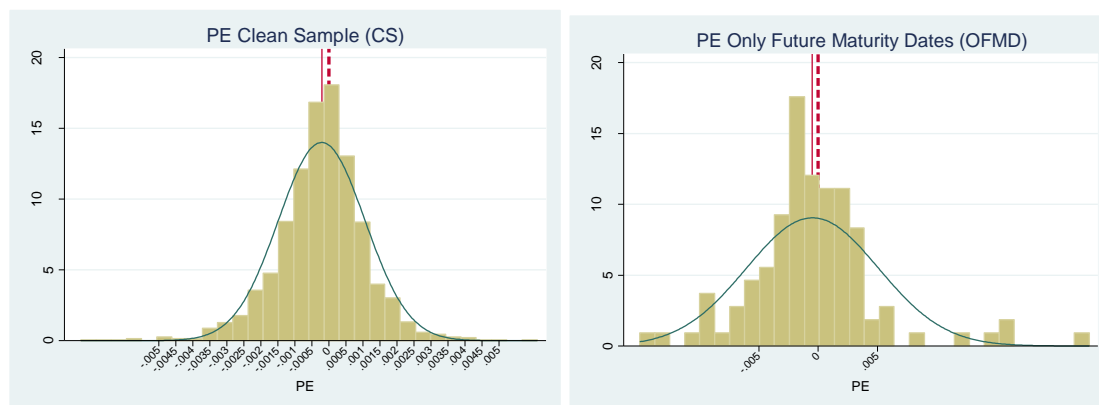
Table 4 shows that both the mean and the standard deviation of the Absolute Percentage Error in Only Future Maturity Dates (OFMD) are almost 4 times those corresponding to the Clean Sample (CS), which has been obtained by eliminating OFMD from the full sample (AS). As

mentioned above, this is a consequence of the high level of asynchrony between the closing time of the spot and the futures prices in OFMD.

The histograms of CS and OFMD Percentage Errors are displayed in Figure 1. The dashed lines correspond to the 0% level, whilst the solid lines are the respective means. The normal density functions are represented by the bell curves.

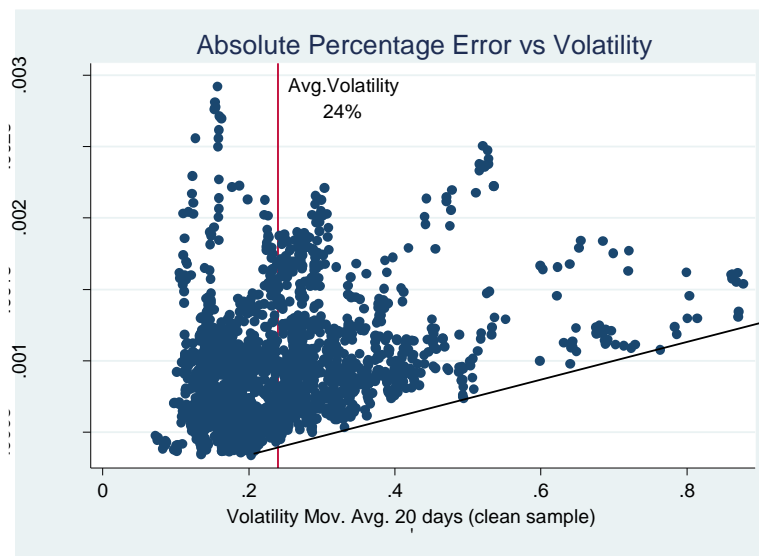
Figure 1

Percentage Error Distribution: Clean Sample and Only Future Maturity Dates



The PE and APE mean and standard deviations for the recent period with negative interest rates (CSIN) do not reveal any substantial differences when compared with those having positive interest rates (CSIP) (table 3 and 4). However, as mentioned above, the CSIN presents a greater percentage of direct arbitrage opportunities with respect to CSIP.

It can also be seen in tables 3 and 4 that the sample of the 100 most volatile days when compared with that of the 100 least present higher errors in terms of MPE and MAPE and their respective standard deviations. A formal relation between the inefficiency of the market and volatility has not been found, but as shown in figure 2, we can at least state that *high volatility periods did not show low errors*.

Figure 2**Absolute Percentage Error vs Volatility (20 days moving average)**

Finally, the results obtained by Wang for the Nikkei have been compared with those of our analysis of the IBEX 35 (table 5)

Table 5**Wang (Nikkei 1997-2005) vs our research for IBEX 35 (2007-2015)**

Stock Index	Percentage Error (PE)		Absolute Percentage Error (APE)	
	Mean (MPE)	Standard Deviation	Mean (MAPE)	Standard Deviation
Nikkei 225 (1997-2005)	-0.04%	0.36%	0.26%	0.25%
All sample (AS) IBEX 35 (2007-2015)	-0.02%	0.17%	0.11%	0.14%
Clean Sample (CS) IBEX 35 (2007-2015)	-0.02%	0.13%	0.09%	0.09%

Source: tables 1, 3 y 4

We can see that the Spanish market presented a better compliance of the *cost of carry* model, which could be due to the fact that the analysed sample of the IBEX 35 is later than that of the Nikkei, which is consistent with the hypothesis that the model tends to comply better when the markets are more developed and subsequently more efficient.

6. Conclusion

The results from previous research as regard the compliance of the non-arbitrage condition between the spot and the future at closing prices are in line with the hypothesis that indicates that the difference between the actual and the theoretical price of the future approaches zero as the market matures. The main conclusion of our study is that, when the compliance of the cost of carry model is analysed for the Spanish market (2007-2015) we obtain a difference in terms of the mean percentage error (MPE) of -0.02%, showing a distribution highly concentrated around 0%. This outcome permits acceptance of the hypothesis that there are no significant differences between the actual daily closing price of the future on IBEX 35 and that of theoretical. Therefore, we can conclude that the cost of carry model holds for the Spanish stock market for the daily closing prices between 2007 and 2015.

Other secondary outcomes are: the most volatile periods present worse compliance of the cost of carry model and that the recent period of negative interest rates had no significant impact in the compliance of the model.

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